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Intentionally remembering or forgetting own- and other-race faces: Evidence from directed forgetting

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Abstract

People are better at remembering faces of their own relative to another ethnic group. This so-called own-race bias (ORB) has been explained in terms of differential perceptual expertise for own- and other-race faces or, alternatively, as resulting from socio-cognitive factors. To directly test predictions derived from these accounts, we examined item-method directed forgetting (DF), a paradigm sensitive to an intentional modulation of memory, for faces belonging to different ethnic and social groups. In a series of five experiments, participants during learning received cues following each face to either remember or forget the item, but at test were required to recognise all items irrespective of instruction. In Experiments 1 and 5, Caucasian participants showed DF for own-race faces only while, in Experiment 2, East Asian participants with considerable expertise for Caucasian faces demonstrated DF for own- and other-race faces. Experiments 3 and 4 found clear DF for social in- and out-group faces. Contrary to recent socio-cognitive models of the ORB, our results suggest that a modulation of face memory by motivational processes is limited to faces with which we have acquired perceptual expertise. Thus, motivation alone is not sufficient to modulate memory for other-race faces and cannot fully explain the ORB.

Abstract

People are better at remembering faces of their own relative to another ethnic group. This so-called own-race bias (ORB) has been explained in terms of differential perceptual expertise for own- and other-race faces or, alternatively, as resulting from socio-cognitive factors. To test predictions derived from the latter account, we examined item-method directed forgetting (DF), a paradigm sensitive to an intentional modulation of memory, for faces belonging to different ethnic and social groups. In a series of five experiments, participants during learning received cues following each face to either remember or forget the item, but at test were required to recognise all items irrespective of instruction. In Experiments 1 and 5, Caucasian participants showed DF for own-race faces only while, in Experiment 2, East Asian participants with considerable expertise for Caucasian faces demonstrated DF for own- and other-race faces. Experiments 3 and 4 found clear DF for social in- and out-group faces. These results suggest that a modulation of face memory by motivational processes is limited to faces with which we have acquired perceptual expertise. Thus, motivation alone is not sufficient to modulate memory for other-race faces and cannot fully explain the ORB.

Keywords: face recognition, own-race bias, directed forgetting, perceptual expertise, motivation to individuate, in-group/out-group

INTENTIONALLY REMEMBERING OR FORGETTING OWN- AND OTHER-RACE FACES: EVIDENCE FROM DIRECTED FORGETTING

Humans demonstrate remarkable performance recognising faces every single day. However, this high level of accuracy does not apply equally to all classes of faces. Of particular interest for the present study, people are usually better at remembering faces of their own relative to a different ethnic group (for a review, see Meissner & Brigham, 2001). This so-called own-race bias (ORB; or other-race effect) is a robust and well-established finding. Failing to correctly recognise an individual can not only negatively impact social interactions, but becomes even more critical in legal contexts where erroneous eyewitness testimonies can lead to wrongful convictions. Given the ORB, such misidentifications appear more likely for other- relative to own-race faces. However, while these applied problems stress the relevance of research on the ORB, the exact mechanisms underlying the phenomenon are still subject to considerable debate.

A first class of theoretical explanations for the ORB focuses on perceptual expertise. These accounts assume that face recognition is optimised for those faces we most regularly encounter, which happen to be own-race faces for most people. On the one hand, reduced contact and the resulting lack of experience with other-race faces has been suggested to result in less efficient perceptual, e.g., configural or holistic processing (Hayward, Crookes, & Rhodes, 2013; Michel, Rossion, Han, Chung, & Caldara, 2006; Tanaka, Kiefer, & Bukach, 2004). On the other hand, representational accounts propose that the multidimensional face-space (MDFS, Valentine, 1991), a psychological space in which individual faces are coded along multiple dimensions, develops through perceptual learning over the lifespan. The dimensions are therefore fine-tuned to optimally distinguish between those faces we encounter most often (i.e., own-race faces), but are not optimal to represent and distinguish between other-race faces (Valentine & Endo, 1992; Valentine, Lewis, & Hills, 2016). Both less efficient perceptual processing and less accurate representations should in turn result in less accurate memory for other-race faces.

Alternatively, socio-cognitive accounts propose that the ORB is strongly affected by motivational factors (Young, Bernstein, & Hugenberg, 2010; Young, Hugenberg, Bernstein, & Sacco, 2012). As one example from this family of theoretical accounts, the Categorization-Individuation Model (CIM, Hugenberg, Young, Bernstein, & Sacco, 2010) suggests three distinct factors to underlie the ORB. First, a fast and automatic categorisation of a given face as belonging to the perceiver's in- or out-group is assumed. This in- versus out-group categorisation is not specific to ethnicity, but can be based on various stimulus characteristics (e.g., age, gender, or even information derived from the context in which the face is presented, such as university affiliation; for a discussion of in- vs. out-group categories, see Hugenberg, Wilson, See, & Young, 2013). While out-group faces are per default not processed beyond this initial detection of category-diagnostic features, in-group faces are individualised, leading to superior memory for this latter category. Second, however, perceiver motives can serve to direct attention to either category- or identity-diagnostic characteristics of a face. Consequently, people are able to individuate out-group (e.g., other-race) faces if sufficiently motivated (Hugenberg, Miller, & Claypool, 2007). Finally, CIM acknowledges the role of prior experience with a given class of faces, such as faces of certain ethnic groups, when discriminating between them. However, expertise is only fully employed for those faces which perceivers are motivated to individuate. To summarise, while expertise accounts assume that difficulties with other-race face recognition stem from a lifetime lack of contact and consequent *inability* to individuate these faces, socio-cognitive accounts posit that perceivers are not *motivated* to individuate other-race faces, but given sufficient motivation would be well able to do so.

In support of the latter suggestion, the ORB has been reported to be absent for faces depicting high-power (Shriver & Hugenberg, 2010) and angry individuals (Ackerman et al., 2006). In addition, individuating instructions can eliminate the ORB (Hugenberg et al., 2007; Rhodes, Locke, Ewing, & Evangelista, 2009; Young et al., 2010). In these studies, participants are informed about the ORB prior to taking part in the experiment. Additionally, they are asked to pay more attention to other-race faces to overcome the ORB and instructed to focus on individuating features in other-race faces. Interestingly, such effects of individuating instructions seem to depend on expertise. Accordingly, two recent studies (Pica, Warren, Ross, & Kehn, 2015; Young & Hugenberg, 2012) reported stronger reduction of the ORB following individuation instructions in participants with high levels of interracial contact. These results can be explained in terms of the CIM (Hugenberg et al., 2010) if one assumes that participants with more other-race contact are also more motivated to individuate other-race faces (and therefore enhanced expertise can become effective). However, it has to be noted that some studies have failed to replicate instruction effects (Tullis, Benjamin, & Liu, 2014; Wan, Crookes, Reynolds, Irons, & McKone, 2015). Similarly, a recent paper by Crookes and Rhodes (2017) found that increased motivation and effort to individuate other-race faces does not necessarily improve other-race face recognition.

Further support for a socio-motivational contribution to the ORB comes from studies in which the ORB is modulated by a second purely social category which is orthogonal to race (e.g., university affiliation). For instance, Shriver, Young, Hugenberg, Bernstein, and Lanter (2008) reported that the ORB is reduced for faces of fellow university students. Moreover, grouping own- and other-race faces according to this social category during learning has been observed to completely eliminate the ORB (Hehman, Mania, & Gaertner, 2010). However, this latter finding was not replicated in a more recent study (Kloth, Shields, & Rhodes, 2014) which found an ORB indendent of whether the faces were grouped according to race or university categories. Taken together, while some studies report socio-motivational factors to strongly modulate the ORB, others have found this modulation to depend on expertise (whereas the CIM suggests that expertise effects depend on motivation) or did not find the respective effects.

In the present series of experiments, we aimed at further testing the role of socio-cognitive and motivational factors to the ORB. To this end, we employed directed forgetting (DF, Bjork, 1970; Woodward & Bjork, 1971), a well-established experimental paradigm sensitive to motivational and intentional aspects of memory, to the study of the ORB.

While previous research has used two variants of the DF procedure, item- and list-method DF (Anderson, 2005; Basden & Basden, 1996; MacLeod, 1999), we will focus on the former paradigm for the present study. In item-method DF, participants receive a cue following each item presented during the learning phase, instructing them to either remember or forget the item. In a subsequent test phase, memory for both to-be-remembered (TBR) and, surprisingly, to-be-forgotten (TBF) items is tested. This typically results in a so-called DF effect, reflecting superior memory for TBR as opposed to TBF items. Item-method DF is thought to result from distinct processes that are intiated upon presentation of the TBR or TBF cues. While a TBR cue results in selective rehearsal and in-depth processing of an item, a TBF cue stops rehearsal and actively inhibits a previously presented item (Anderson & Hanslmayr, 2014; Basden, Basden, & Gargano, 1993; Fawcett & Taylor, 2008; Nowicka, Jednorog, Wypych, & Marchewka, 2009; Paz-Caballero, Menor, & Jimenez, 2004).

Traditionally, experiments using the DF paradigm have employed verbal material. More recently, however, the DF procedure has also been applied to other types of stimuli, such as line drawings (Lehman, McKinley-Pace, Leonard, Thompson, & Johns, 2001) and pictures (e.g., Hauswald & Kissler, 2008; Hauswald, Schulz, Iordanov, & Kissler, 2011). These studies usually replicate the DF effect obtained with verbal material, although it is sometimes smaller in size (Basden & Basden, 1996; Hauswald & Kissler, 2008; Paller, Bozic, Ranganath, Grabowecky, & Yamada, 1999; Quinlan, Taylor, & Fawcett, 2010). So far, only very few studies have investigated DF using faces. A DF effect is typically reported in these studies (Fitzgerald, Price, & Oriet, 2013; Goernert, Corenblum, & Otani, 2011; Metzger, 2011; Paller et al., 1999; but see Reber et al., 2002), suggesting that memory for faces is to some extent susceptible to intentional forgetting.

At a first glance, the suggestion to use DF to investigate socio-cognitive and expertise-related mechanisms of the ORB might appear counterintuitive. Both categorising faces into social in- versus out-groups and expertise-based perceptual mechanisms are supposed to be immediately engaged upon presentation of the face stimulus whereas the DF instructions are not delivered until *after the offset* of the stimulus. Closer consideration, however, might render this paradigm interesting for the present research question. More specifically, at stimulus onset participants do not know whether the face will be followed by a TBR or TBF cue, and this applies equally to own- and other-race faces. Accordingly, participants may *initially* be motivated to process all faces as they wait for the instruction to either remember or forget the face. Upon presentation of the memory cues, the instruction should then modulate the extent to which faces are further processed in memory. As described above, a TBR cue should elicit further elaborative processing and rehearsal, whereas a TBF cue should result in dropping the respective items from rehearsal and/or inhibiting them (e.g., Basden et al., 1993). While, as discussed in the previous paragraphs, faces have generally been shown to be susceptible to DF, here we were particularly interested in the extent to which DF can modulate memory for own- and other-race faces, respectively. As will be explained in more detail below, we suggest that different predictions for DF of own- and other-race faces can be derived from expertise- and socio-cognitive accounts.

In the following, we report five experiments which systematically investigated the influence of intentional forgetting on memory for faces of different categories. In particular, we examined DF for own- and other-race faces in Caucasian (Experiments 1 and 5) and East Asian participants living in the UK (Experiment 2). In addition, DF was applied to purely social in- and out-group faces (Experiment 3) as well as own- and other-gender faces (Experiment 4).

Experiment 1

Experiment 1 investigated DF for own- and other-race faces to test predictions derived from expertise-related and socio-cognitive explanations of the ORB. First, expertise accounts propose that, due to a lack of experience, other-race faces are not optimally processed and/or represented, and therefore predict differential DF effects for own- and other-race faces. More specifically, for own-race faces, a detailed and accurate representation for each individual stimulus is created, which is distinct from (most) other representations. A cue to remember should encourage the transfer of this representation into long-term memory, while a cue to forget should prevent further processing and/or inhibit the representation. Accordingly, we expected better memory for TBR compared to TBF items. For any individual other-race face, however, the representation will be substantially less precise, and will be similar to other representations of other-race faces. Therefore, while an instruction to remember the face will transfer the representation into memory, it will be similar to other representations, resulting in enhanced confusion among them at test (and accordingly increased false alarm/lower correct rejection rates). Importantly, while an instruction to forget will inhibit this specific representation, other highly similar representations will exist in memory. Paradoxically, even if participants successfully inhibit an other-race face during learning, when presented as a test item, this "forgotten" face will look similar to other stimuli that were successfully encoded, and will therefore be more likely mixed up with a different representation and then "falsely remembered"[1]. Accordingly, no or only a small DF effect for other-race faces would be expected.

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[1] Note that these falsely remembered faces are not false alarms in classic signal detection terms, which are false positive reponses to de facto new items. What we suggest here is that participants will more likely make correct

Alternatively, socio-cognitive accounts suggest that the ORB results from a tendency to individuate own-race faces but to process only category-diagnostic information in other-race faces. The CIM (Hugenberg et al., 2010) additionally posits that perceiver motives can serve to direct attention to identity-diagnostic information in both own- and other-race faces. Accordingly, participants should be able to individuate other-race faces if these are perceived as sufficiently important. In the DF paradigm, participants are instructed to remember half of the faces but not the other half. Which faces are important (i.e., need to be remembered) can only be known when the face is no longer on the screen, so to optimise performance participants should try to remember all faces until the cue is presented. Importantly, this situation is identical for own- and other-race faces. As both own- and other-race faces can be followed by a TBR cue, and may therefore be important, the initial uncertainty about a specific face's relevance should increase motivation to remember both own- and other-race faces. Thus, assuming that people *are able* to individuate all faces if they are sufficiently motivated, we would expect a clear DF effect for both own- *and* other-race faces. If participants were able and motivated to individuate both own- and other-race faces, the resulting representations should be similarly accurate and detailed. TBR cues should then elicit transfer of both own- and other-race items into long-term memory, while a TBF cue should stop further rehearsal and inhibit both own- and other-race faces. Accordingly, we would expect better memory for TBR compared to TBF faces for both stimulus categories.

Method

Participants

36 undergraduate and postgraduate students (18 – 32 years, $M = 20.22$, $SD = 3.01$, 32 female) gave written informed consent to take part in the study. All had a Caucasian ethnic background and normal or corrected-to-normal vision. Participants received course credit or £5 for partaking. The study was approved by the local Ethics Committee.

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old responses to other-race TBF items, not because they remember the specific face but because they mix it up with a similar and successfully encoded item.

Stimuli and apparatus

A set of 128 colour photographs of unfamiliar faces was used as stimuli (for origin of images and more detailed information regarding ratings of ethnic typicality, see Wiese, Kaufmann, & Schweinberger, 2014). The selected photographs displayed portraits with full frontal views and neutral expressions. Half of the photographs depicted Caucasian faces, the other half were of East Asian faces. Half of the faces within the respective ethnic categories were female. Using Adobe Photoshop (CS4 Extended, 11.0.2), faces were cut out to remove any extraneous information (e.g., clothing, background) and pasted to a uniform black background. Stimuli were framed within an area of 300 x 400 pixels (10.9 x 15.6 cm) resulting in a visual angle of 6.2° x 8.9° at a viewing distance of approximately 100 cm. All stimuli were presented on dark grey background in the centre of a computer monitor with a screen resolution of 1280 x 1024 pixels using E-Prime (2.0). Following the experiment, participants were asked to provide judgements of quality of contact towards Caucasian and East Asian people on a scale from 1 to 4 (1 – very superficial, 2 – rather superficial, 3 – rather intense, 4 – very intense, Wiese, 2012).

Procedure

The study consisted of a learning and a test phase. The learning phase comprised four blocks with 16 trials each. In each block, an equal number of Caucasian and East Asian faces (50% female respectively) were presented. Within each respective ethnic category, half of the faces were followed by an instruction to remember, the other half by an instruction to forget. Within each block, all trials were presented in random order. Each trial started with a fixation cross for 1,000 ms, followed by the face stimulus which remained on the screen for 750 ms. The stimulus was replaced by a mask (phase-randomised version of a face stimulus) presented for 250 ms to preclude visual aftereffects. Finally, participants were instructed via letter cues presented for 3,000 ms to either remember ("RRR") or forget ("FFF") the face previously presented (Figure 1a).

During the test phase, and surprising to the participants, *all* 64 items from the learning phase (i.e., both TBR and TBF items) as well as 64 new items (again 50% female, 50% East Asian) were presented for 3,000 ms or, in case of faster responses, until the participants pressed a response key. Face stimuli were separated by a fixation cross (presented for 1,000 ms). For each face, participants had to indicate via left and right index finger key presses whether the face had been presented during learning or not. Stimuli were presented in random order, and the assignment of keypresses, the assignment of stimuli to first appear during learning or test, as well as the assignment of remember/forget instructions to learning phase stimuli was counterbalanced across participants.

Statistical analyses of recognition accuracy were performed using repeated measures analyses of variance (ANOVA) with factors ethnicity (Caucasian, East Asian) and instruction (remember, forget). Differences in participants' memory performance for own- and other-race faces was tested using a signal detection theory measure of sensitivity (*d*', e.g., Wickens, 2002). *d*' was computed by subtracting z-standardised false alarm rates from z-standardised hit rates for TBR faces for Caucasian and East Asian faces separately. Differences in *d*' for Caucasian and East Asian faces were analysed using paired samples t-tests. Moreover, correct rejections of Caucasian and East Asian faces presented as new items at test were again compared via paired samples t-tests.

Complementing these standard statistical procedures, we additionally adopted an estimation approach (see Cumming, 2012; Cumming & Calin-Jageman, 2017). In particular, we report point estimates of effect sizes (Cohen's *d*) and their corresponding 95% confidence intervals (CIs). As suggested by Cumming and Calin-Jageman (2017), Cohen's *d* for paired samples t-tests was corrected for bias and calculated by using mean SD instead of the SD of the difference as the denominator (Cohen's d_{unb}). Calculation of effect sizes and confidence intervals was performed with ESCI (Cumming & Calin-Jageman, 2017).

Results

Contact Questionnaire

A paired samples t-test on quality of contact revealed significantly higher quality of contact to Caucasian (M = 3.333, 95% CI [3.10, 3.56]) than East Asian people (M = 1.861, 95% CI [1.58, 2.14]), $t(35) = 8.37$, $p < .001$, $M_{\text{diff}} = 1.472$, 95% CI [1.12, 1.83], Cohen's $d_{\text{unb}} = 1.898$, 95% CI [1.29, 2.57].

Performance

A repeated measures ANOVA with the within-subjects factor ethnicity (Caucasian, East Asian) and instruction (remember, forget) on hit rates resulted in a significant main effect of instruction, $F(1,35) = 7.61$, $p = .009$, $\eta^2_p = .179$, with superior memory for items cued to remember compared to items cued to forget. Importantly, this main effect was further qualified by a significant ethnicity x instruction interaction, $F(1,35) = 11.28$, $p = .002$, $\eta^2_p = .244$ (Figure 2a). Follow-up tests showed that the DF effect (R - F) was statistically significant for Caucasian faces, $t(35) = 3.72$, $p = .001$, $M_{\text{diff}} = 0.133$, 95% CI [0.06, 0.21], Cohen's $d_{\text{unb}} = 0.789$, 95% CI [0.34, 1.27], but not for East Asian faces, $t(35) = -0.41$, $p = .683$, $M_{\text{diff}} = -0.010$, 95% CI [-0.06, 0.04], Cohen's $d_{\text{unb}} = -0.062$, 95% CI [-0.36, 0.24] (Figure 2b).

A paired samples t-test on correct rejection (CR) rates yielded significantly higher CR rates for Caucasian (M = .807, 95% CI [0.76, 0.85]) than for East Asian faces (M = .681, 95% CI [0.63, 0.73]), $t(35) = 4.85$, $p < .001$, $M_{\text{diff}} = 0.127$, 95% CI [0.07, 0.18], Cohen's $d_{\text{unb}} = 0.897$, 95% CI [0.48, 1.34] (Figure 2a). A paired samples t-test on d' revealed higher sensitivity for own-race Caucasian (M = 1.265, 95% CI [1.00, 1.53]) over other-race East Asian faces (M = 0.595, 95% CI [0.42, 0.77]), $t(35) = 6.23$, $p < .001$, $M_{\text{diff}} = 0.671$, 95% CI [0.45, 0.89], Cohen's $d_{\text{unb}} = 0.989$, 95% CI [0.61, 1.40].

Discussion

Experiment 1 investigated Caucasian participants' memory for own- and other-race faces. The main aim was to test the potential effect of motivation on the ORB by employing the DF paradigm. A significant DF effect was obtained for own-race faces, revealing better memory for items cued to remember compared to items cued to forget. This finding is in line with previous work (Fitzgerald et al., 2013; Goernert et al., 2011; Metzger, 2011; Paller et al., 1999) demonstrating that memory for faces can be intentionally modulated. Importantly, the DF effect was further found to depend on the ethnicity of the faces, as it was absent for other-race faces. We suggest that this pattern would not be predicted by a socio-cognitive account that proposes motivational factors to influence memory for other-race faces. At the same time, it appears more in line with an expertise-based explanation of the ORB. As discussed in more detail above, the DF paradigm should motivate participants to process all faces until the TBR or TBF cue is presented. If motivation allows to adequately represent all faces until the cue is presented, effects of the memory cue should be similar for own- and other-race faces. If, however, perceptual expertise is substantially smaller for other-race faces, perceptual and cognitive processing stages before the presentation of the memory cue will not work as efficiently, resulting in a less accurate representation available when the TBR/TBF cue is shown. A less accurate representation will not only make it more likely that learned and novel faces are mixed up at test (as observed in the dereased correct rejection rate in the present experiment), but also in more similar performance for TBR and TBF items, as “forgotten” other-race faces will be more likely confused with representations of remembered faces.

Of note, Fitzgerald et al. (2013) investigated DF for other-race faces in Caucasian participants and observed significant effects for Asian and Black faces. However, as participants were only tested on other-race faces, this study precludes a comparison of DF effects for own- and other-race faces, and the calculation of a potential ORB. Importantly, the finding of a DF effect for other-race faces per se does not contradict our explanation of the present pattern of results, as one might assume that DF effects for own-race faces would have been even larger in the participants tested by Fitzgerald and colleagues (2013).

The results of Experiment 1 thus suggest that a modulation of face memory by the intention to remember is largely limited to those faces for which expertise has been acquired.

Alternatively, however, it remains possible that differential DF effects for own- and other-race faces simply resulted from varying difficulty of the two stimulus sets, independent of perceptual expertise. In a next step, we therefore tested a group of East Asian participants with the same experiment. The finding of a DF effect for East Asian faces in East Asian participants would rule out a potential stimulus effect independent of expertise in Experiment 1.

Experiment 2

In Experiment 2, we tested a group of East Asian students who had been living in the UK for several months during which they had individuating contact to Caucasian people. This type of contact has previously been shown to be sufficient to reduce the ORB (e.g., Wiese et al., 2014). Our participants had thus acquired expertise with Caucasian faces before the experiment, but at the same time likely still perceived these faces as belonging to a social out-group. Therefore, if expertise is a prerequisite for the DF effect in face memory as suggested by Experiment 1, and our East Asian sample had acquired expertise with both ethnic groups, we would predict DF effects for both own- and other-race faces. Similarly, if, as suggested by socio-cognitive accounts, motivation to individuate can modulate memory for both in- and out-group faces, and the experimental procedure encourages an initial motivation to individuate all faces, DF effects for both ethnic groups would be expected. Accordingly, Experiment 2 was not designed to distinguish between the two theoretical explanations of the ORB. If, however, the results of Experiment 1 were simply driven by differences in general difficulty of stimulus sets independent of expertise, we would expect to again find a DF effect for Caucasian, in this case other-race faces only.

Method

Participants

24 undergraduate and postgraduate students (18 – 31 years, *M* = 20.83, *SD* = 3.13, 21

female) with an East Asian ethnic background were tested. They had been living in the UK for 4 to 48 months prior to the experiment. All had normal or corrected-to-normal vision and were compensated analogously to Experiment 1. Participants gave written informed consent, and the study was approved by the local Ethics Committee.

Procedure

All stimuli and experimental parameters were identical to Experiment 1.

Results

Contact Questionnaire

A paired samples t-test showed significantly higher quality of contact to own-race East Asian (M = 3.125, 95% CI [2.71, 3.54]) compared to other-race Caucasian people (M = 1.958, 95% CI [1.62, 2.30]), $t(23) = 4.07$, $p < .001$, $M_{\text{diff}} = 1.167$, 95% CI [0.57, 1.76], Cohen's $d_{\text{unb}} = 1.248$, 95% CI [0.56, 2.00]. We note, however, that the effect size is substantially smaller as compared to Experiment 1[2].

Performance

An ANOVA with factors ethnicity (Caucasian, East Asian) and instruction (remember, forget) on hit rates yielded a significant main effect of instruction, $F(1,23) = 9.47$, $p = .005$, $\eta^2_p = .292$, again showing better memory for TBR than TBF items (Figure 3a). A significant main effect of ethnicity was not observed, $F(1,23) = 0.09$, $p = .763$, $\eta^2_p = .004$, and the ethnicity x instruction interaction failed to reach significance as well, $F(1,23) = 0.01$, $p = .966$, $\eta^2_p < .001$ (Figure 3b).

A paired samples t-test revealed comparable CR for Caucasian (M = 0.711, 95% CI [0.66, 0.76]) and East Asian faces (M = 0.748, 95% CI [0.70, 0.80]), $t(23) = -1.46$, $p = .158$, $M_{\text{diff}} = -0.037$, 95% CI [-0.09, 0.02], Cohen's $d_{\text{unb}} = -0.307$, 95% CI [-0.75, 0.12] (Figure 3a). Similarly, d' for Caucasian (M = 0.935, 95% CI [0.64, 1.23]) and East Asian faces (M = 1.042,

[2] Although both effect sizes are considered large (e.g., Cumming, 2012), the effect size in Experiment 2 (d = 1.248) is about 65% of the one measured in Experiment 1 (d = 1.898), which reflects a substantial difference.

95% CI [0.80, 1.29]) did not differ significantly, $t(23) = -0.86$, $p = .399$, $M_{\text{diff}} = -0.108$, 95% CI [-0.37, 0.15], Cohen's $d_{\text{unb}} = -0.163$, 95% CI [-0.55, 0.22].

Discussion

Experiment 2 aimed at ruling out the possibility that the findings of Experiment 1 were driven by generally higher difficulty for the East Asian stimulus set rather than differences in expertise for own- versus other-race faces. As in Experiment 1, a significant DF effect was obtained. Unlike Experiment 1, however, this effect was not further qualified by ethnicity, and comparable DF effects for Caucasian and East Asian faces were observed. Similarly, an advantage for own- over other-race faces in correct rejection rates and *d*', as found for Caucasian participants in Experiment 1, was absent in the current sample of East Asian participants.

Together, the findings of Experiments 1 and 2 show that memory for faces of different ethnicities can be intentionally modulated with the DF procedure. Furthermore, the comparable DF effect for own- and other-race faces in East Asian participants in Experiment 2 suggests that Experiment 1's findings of significant DF effects for own- but not other-race faces were not driven by general differences in difficulty of the two stimulus sets. In a next step, the DF procedure was applied to a minimal group paradigm (see Bernstein, Young, & Hugenberg, 2007). Our aim was to investigate whether DF effects for in- but not out-group faces occur when group status is determined exclusively by social factors and cannot be affected by perceptual expertise.

Experiment 3

Although differences in general stimulus difficulty and motivation appear unlikely explanations given the previous two experiments, it remains possible that a socio-cognitive factor other than motivation to individualise underlies the differential DF observed in Experiment 1. More specifically, socio-cognitive accounts suggest that other-race faces are automatically classified as belonging to a social out-group and then processed at a categorical rather than individual level (Sporer, 2001). While the CIM suggests that motivation to individuate is capable of modulating the processing of out-group faces, the procedure in the DF paradigm might not be sufficient to elicit this process. If so, less accurate representations of out-group faces would be created. This in turn might still explain the findings of Experiment 1 without necessarily assuming differences in perceptual expertise as the underlying mechanism.

In an attempt to test this possibility, we examined DF for purely social in- and out-group faces. Such in- and out-groups (e.g., own- versus other university affiliation) do not systematically differ with respect to facial characteristics, and indeed face stimuli are randomly assigned to these groups. Any difference in memory is then highly likely driven by factors related to social group membership and cannot be explained in terms of differential perceptual expertise. Previous research reported that labelling (own-race) faces as belonging to the participant’s own versus a different university is sufficient to elicit a memory advantage for in- versus out-group faces (Bernstein et al., 2007). The same pattern was observed for experimentally created in- and out-groups (i.e., randomly assigning participants to a “red” vs. “green” personality type).

To further distinguish between automatic categorisation versus individuation of in- and out-group faces on the one hand and an explanation on the basis of perceptual expertise on the other hand, we examined DF for faces belonging to purely social in- versus out-groups which did not differ with respect to expertise. If the pattern of clear DF effects for own- but not other-race faces observed in Experiment 1 was driven by social categorisation, a similar result with DF effects for purely social in- but not out-group faces would be expected in Experiment 3. If, however, the pattern of Experiment 1 resulted from perceptual expertise, we would expect comparable DF effects for purely social in- and out-group faces.

Method

Participants

32 undergraduate and postgraduate students (18 -30 years, $M = 20.31$, $SD = 3.04$, 29 female) took part in the study. All had normal or corrected-to-normal vision, and were compensated as described for Experiment 1. The study was approved by the local Ethics Committee.

Stimuli and apparatus

The stimulus set comprised 128 colour photographs of unfamiliar Caucasian faces (50% female). Photographs were taken from various face data bases (see Wiese et al., 2014). Selection criteria and editing of images were identical to Experiment 1. Moreover, ten items were randomly selected from a personality inventory (NEO-PI-R, Costa & McCrea, 1992).

Procedure

The procedure was identical to Experiment 1 except for the following changes. At the beginning of the experimental session, participants completed a short personality questionnaire. Items (e.g., I laugh easily; I try to perform all tasks assigned to me conscientiously; I strive for excellence in everything that I do) were presented individually on a screen until participants typed in their response, with keys assigned to five possible response options (strongly disagree, disagree, neutral, agree, and strongly agree). Participants were then told that they were a "red" or "green" personality. Unbeknown to the participants, the assignment of participants to these categories was completely arbitrary and unrelated to the answers given in the questionnaire, which were de facto not analysed. We chose real items from a commonly used personality inventory to corroborate authenticity of the procedure. To further increase credibility, participants were given red or green wristbands to wear during the experiment and received exactly the same information about their groups as originally provided by Bernstein et al. (2007, p.710).

During the learning phase of the following recognition memory experiment, a red or green frame was placed around the face stimulus (with equal probability), which indicated whether the face belonged to the participants' in- or out-group with respect to "personality type" (Figure 1b). Assignment of red or green frames to the face stimuli was counterbalanced across participants. Additionally, as in Experiment 1, we counterbalanced the assignment of stimuli to learning and test phase of the experiment, and the assignment of remember/forget instructions to the face stimuli within the learning phase set.

Results

Performance

A repeated measures ANOVA with factors group membership (in-group, out-group) and instruction (remember, forget) on hit rates yielded a significant main effect of instruction, $F(1,31) = 4.25$, $p = .048$, $\eta^2_p = .121$, with higher accuracies for TBR as opposed to TBF items. Neither the main effect of group membership, $F(1,31) = 0.29$, $p = .596$, $\eta^2_p = .009$, nor the group membership x instruction interaction, $F(1,31) = 1.79$, $p = .191$, $\eta^2_p = .055$, were statistically significant (Figure 4a, b). We additionally conducted a t-test comparing the hit rates for in- and out-group TBR faces to assess whether the manipulation of group membership was effective for TBR faces, the condition which is closest to the original procedure reported by Bernstein et al. (2007). Hit rates for TBR in- and out-group faces did not differ significantly, $t(31) = -0.48$, $p = .635$, $M_{\text{diff}} = -0.014$, 95% CI [-0.08, 0.05], Cohen's $d_{\text{unb}} = -0.088$, 95% CI [-0.46, 0.28].

CR rate (M = 0.783, 95% CI [0.75, 0.82], Figure 4a) was comparable to Experiments 1 and 2. A paired samples t-test on *d'* revealed comparable performance for in- ($M = 0.965$, 95% CI [0.78, 1.15]) and out-group faces ($M = 0.996$, 95% CI [0.80, 1.19]), $t(31) = -0.37$, $p = .711$, $M_{\text{diff}} = -0.034$, 95% CI [-0.20, 0.14], Cohen's $d_{\text{unb}} = -0.056$, 95% CI [-0.36, 0.25].

Discussion

Experiment 3 investigated DF effects for purely social in- versus out-group faces to further distinguish between socio-cognitive and expertise-based explanations of the results obtained in Experiment 1, which found DF for own- but not other-race faces. Our analysis revealed a significant main effect of memory instruction, with more accurate memory for TBR than TBF faces. Unlike Experiment 1, this DF effect did not interact with social in- and out-group category, reflecting in principle the pattern expected under an expertise-based explanation of the ORB.

At variance with Bernstein et al. (2007), we did not find evidence for differential recognition of purely social in- versus out-group faces. Therefore, one might argue that the manipulation of group membership was unsuccessful, and it may therefore seem meaningless to test for differential DF for in- and out-group faces. The failure to replicate the effect observed by Bernstein et al. (2007) was unexpected, in particular because we followed their design as closely as possible, using the same basic procedure and identical instructions. However, we aknowledge that the additional DF manipulation during learning might have increased processing demands compared to Bernstein et al. (2007). At the same time, the DF procedure gave rise to an ORB in Experiment 1. Accordingly, although it is possible that the group membership manipulation might have increased task demands in the present experiment, this would suggest that a memory bias resulting from a minimal group paradigm is generally less robust than the ORB (see also Herzmann & Curran, 2013). An alternative, and not mutually exclusive, explanation could be that group membership was indicated by an additional cue (i.e., coloured frame) that was external to the face (whereas race is inherent in the face). This frame may, at least to a certain extent, have directed attention away from the face given that it needed to be encoded along with the face, resulting in a somewhat weaker representation for in- and out-group faces compared to those formed for own-race faces in Experiment 1. While speculative at present, this may perhaps explain why the DF effect in Experiment 3 was overall substantially smaller compared to the effect observed for own-race faces in Experiment 1.

In Experiment 4, we undertook a further attempt to examine whether the results of Experiment 1 reflected automatic categorisation into in- or out-groups or differences in perceptual expertise. This time, we investigated DF effects for own- and other-gender faces.

Experiment 4

In Experiment 3, we only observed small DF effects for in-and out-group faces. In addition, and at variance with Bernstein et al. (2007), we did not find evidence for a successful manipulation of group membership. Therefore, it could be argued that a failure to provide evidence for a social categorisation manipulation in the first place makes it pointless to test hypotheses regarding DF for in- and out-group faces, respectively.

In Experiment 4, a further attempt was undertaken to investigate whether Experiment 1's finding of DF for own- but not other-race faces resulted from automatic categorisation into in- or out-groups or differential perceptual expertise. To this end, we investigated DF for own- and other-gender faces in female participants. The own-gender bias (for a review, see Herlitz & Loven, 2013) refers to better memory for own- than for other-gender faces and is often found to be reliable in female, but not in male, participants (e.g., Wiese & Schweinberger, 2018), although the exact pattern of results is not entirely consistent across studies (e.g., Steffens, Landmann, & Mecklenbräuker, 2013; Wolff, Kemter, Schweinberger, & Wiese, 2014; Wright & Sladden, 2003). The own-gender bias is mostly considered to be unrelated to expertise as most people in Western societies have similar contact with male and female faces (for an alternative developmental framework, see Herlitz & Loven, 2013).

As in Experiment 3, we reasoned that if the result of DF for own- but not other-race faces in Experiment 1 was driven by an automatic categorisation of faces into in- and out-groups, we would expect to find DF for own- but not other-gender faces. By contrast, if the pattern of results obtained in Experiment 1 reflected differential expertise with own- and other-race faces, DF effects would be expected for both own- and other-gender faces.

Method

Participants

36 female Caucasian undergraduate and postgraduate students (18 – 28 years, *M* = 19.56, *SD* = 1.82) consented to take part in the experiment. All had normal or corrected-to-normal vision, and were compensated as described for Experiment 1. The study received ethical approval from the local ethics committee.

Stimuli and apparatus

The stimulus set used in this experiment was identical to that used in Experiment 3. However, as this experiment investigated DF for own- and other-gender faces, both the personality inventory and the coloured frames were no longer required.

Procedure

The procedure was identical to that of Experiment 1 except that all stimuli now depicted Caucasian faces and gender of the stimuli replaced ethnicity as a factor in all of the analyses.

Results

A repeated measures ANOVA with the within-subjects factors gender (female, male) and instruction (remember, forget) on hit rates revealed a significant effect of instruction, $F(1,35) = 35.02$, $p < .001$, $\eta_p^2 = .500$, with better performance for TBR compared to TBF faces (Figure 5a). While the main effect of gender was not significant, $F(1,35) = 0.96$, $p = .333$, $\eta_p^2 = .027$, the gender x instruction interaction approached significance, $F(1,35) = 3.43$, $p = .072$, $\eta_p^2 = .089$. Post-hoc comparisons revealed significant DF effects for female, $t(35) =$

6.49, $p < .001$, $M_{diff} = 0.163$, 95% CI [0.11, 0.21], Cohen's $d_{unb} = 1.080$, 95% CI [0.68, 1.52], and male faces, $t(35) = 3.29$, $p = .002$, $M_{diff} = 0.101$, 95% CI [0.04, 0.16], Cohen's $d_{unb} = 0.620$, 95% CI [0.22, 1.04], with larger effect sizes for female faces (Figure 5b). A comparison of hit rates for TBR female and male faces revealed a trend for better memory for TBR female relative to male faces, $t(35) = 1.93$, $p = .062$, $M_{diff} = 0.054$, 95% CI [-0.01, 0.11], Cohen's $d_{unb} = 0.324$, 95% CI [-0.02, 0.67].

A paired samples t-test on CR revealed comparable performance for female ($M = 0.800$, 95% CI [0.76, 0.84]) and male faces ($M = 0.836$, 95% CI [0.79, 0.88]), $t(35) = -1.75$, $p = .089$, $M_{diff} = -0.037$, 95% CI [-0.08, 0.01], Cohen's $d_{unb} = -0.279$, 95% CI [-0.61, 0.04] (Figure 5a). Similarly, d' for female ($M = 1.263$, 95% CI [1.05, 1.48]) and male faces ($M = 1.300$, 95% CI [1.06, 1.54]), $t(35) = -0.34$, $p = .736$, $M_{diff} = -0.035$, 95% CI [-0.24, 0.17], Cohen's $d_{unb} = -0.050$, 95% CI [-0.35, 0.25], did not differ significantly.

Discussion

In Experiment 4, we again found significant DF effects, reflecting better memory for TBR compared to TBF faces. In contrast to Experiment 1, the present experiment revealed substantial DF for both own- and other-gender faces, reflecting the pattern of results which would be predicted under a perceptual expertise-based explanation of the ORB. As both own- and other-gender faces in Experiment 4 were from the participants' ethnic group, this theorerical account would assume clear effects for the two face categories if DF were driven by expertise. We suggest, however, that the current pattern of results would not be expected from a socio-cognitive perspective. If automatic categorisation resulted in less pronounced individuation of social out-group faces (e.g., Hugenberg et al., 2010; Sporer, 2001) and therefore less accurate representations for these stimuli, we would have expected a result similar to Experiment 1, in which ethnic in-group faces elicited a DF effect, but out-group faces did not.

In the present study, an own-gender memory bias was absent in female participants in both accuracies and *d'*, which is reminiscent of the finding of comparable memory for in- and out-group faces in Experiment 3. We have noted above that the failure to find differential memory for in- and out-group faces might mean that the manipulation of group membership was unsuccessful and that it might therefore be inadequate to expect in- and out-group faces to be differentially affected by DF. Given the absence of an own-gender bias in the present experiment, a similar argument could in principle be made here as well. However, it appears less plausible to assume that the gender of the faces was not processed relative to the arbitrary social category used in Experiment 3. Of note, and in contrast to Experiment 3, the present study revealed a trend for a significant interaction, pointing to somewhat more pronounced DF for own- relative to other-gender faces. Moreover, this trend seems to be mostly driven by higher hit rates for female versus male faces in the TBR condition. Of note, a corresponding effect was not detected for in- and out-group faces in Experiment 3. This may be taken to suggest that gender was a sufficiently salient dimension to elicit social categorisation, as own- and other-gender faces were somewhat differentially remembered. However, we acknowledge that the evidence for a successful categorisation of own- and other-gender faces into in- and out-groups is not particularly strong in the present experiment, and that further reseach is needed to increase confidence in the present results.

In the previous paragraph, it has tentatively been suggested that higher hit rates for female compared to male TBR faces indicate social categorisation of faces into in- and out-groups. At the same time, we have argued that the finding of substantial DF for both own- and other-gender faces supports an expertise-based explanation of the results obtained in Experiment 1. At a first glance, these suggestions might be seen as being in opposition. We note, however, that while DF in Experiment 1 was evident for own-race faces, it was very clearly absent for other-race faces (Figure 2b). In Experiment 4, both own- and other-gender faces gave rise to DF. We therefore conclude that while, as suggested above, evidence for a successful social categorisation is not particularly strong at present, the finding of DF for both own- and other-gender faces is clearly in line with our previous suggestion that a modulation of face memory by intentional processes is limited to faces we have expertise with.

Interestingly, although Experiments 3 and 4 used the same stimulus set, DF effects were substantially more pronounced in Experiment 4. As discussed above, this might reflect increased processing demands in Experiment 3 due to social group membership being indicated by coloured frames placed around the face images. By contrast, Experiment 4 used a more “natural” social category (i.e., gender) that, similar to race, is derived from the face itself.

Experiment 5

Experiments 1 to 4 all showed significant DF effects. However, a significant interaction of DF with face category has so far only been detected in Experiment 1. We interpreted this finding to reflect that DF cues can only become effective when participants have sufficient expertise with the respective face category. It could also be argued, however, that a failure to find DF effects for other-race faces in Experiment 1 might be related to chance level performance for TBR and TBF other-race faces. While CR were generally well above 50% and thus provide evidence against simple guessing, we reasoned it would nonetheless be beneficial to replicate the findings of Experiment 1. We therefore conducted another experiment to investigate DF of own- and other-race faces in Caucasian participants. To address the above concerns, we decreased task difficulty by reducing the number of stimuli in each learning block. Moreover, we only tested female participants with female face stimuli, as this combination has been shown to result in highest accuracies in a recent meta-analysis (Herlitz & Loven, 2013).

As these changes did not affect our participants' increased level of expertise with own- relative to other-race faces, we expected to replicate the result of Experiment 1. In particular, we hypothesised that Caucasian participants with limited other-race contact would demonstrate DF for own- but not other-race faces. This finding would further strengthen our previous suggestion that a modulation of memory by the intention to remember is largely restricted to faces for which a substantial amount of perceptual expertise has been acquired.

Method

Participants

36 female undergraduate and postgraduate students (18 – 43 years, $M = 22.08$, $SD = 5.61$) with a Caucasian ethnic background took part in the experiment and received course credit for participating. All had normal or corrected-to-normal vision and were compensated as described for Experiment 1. The study was approved by the local ethics committee.

Stimuli and apparatus

96 colour photographs of unfamiliar faces were used as stimuli which were taken from various databases (see Wiese et al., 2014). As in Experiment 1, half of these showed Caucasian faces, while the other half depicted East Asian faces. At variance with Experiments 1-4, only female faces were shown. Participants were again required to provide ratings of quality of contact with Caucasian and East Asian people after the main experiment (Wiese, 2012).

Procedure

The procedure was identical to Experiment 1 except that we reduced the number of stimuli presented in each block from 16 to 12, resulting in a total of 48 stimuli presented during learning. At test, these images were presented in random order, intermixed with 48 new items (50% Caucasian).

Results

Contact Questionnaire

A paired samples t-test on quality of contact revealed significantly higher quality of contact to Caucasian (M = 3.556, 95% CI [3.32, 3.79]) than East Asian people (M = 1.750, 95% CI [1.48, 2.02]), $t(35) = 10.18$, $p < .001$, $M_{\text{diff}} = 1.806$, 95% CI [1.45, 2.17], Cohen's $d_{\text{unb}} = 2.348$, 95% CI [1.67, 3.12].

Performance

A repeated measures ANOVA with the within-subjects factors ethnicity (Caucasian, East Asian) and instruction (remember, forget) on hit rates revealed a significant main effect of instruction, $F(1,35) = 4.39$, $p = .044$, $\eta_p^2 = .111$, indicative of higher accuracies for TBR than TBF faces (Figure 6a). Crucially, we also observed a significant ethnicity x instruction interaction, $F(1,35) = 8.66$, $p = .006$, $\eta_p^2 = .198$. Post-hoc comparisons yielded a significant DF effect for Caucasian faces, $t(35) = 3.38$, $p = .002$, $M_{\text{diff}} = 0.107$, 95% CI [0.04, 0.17], Cohen's $d_{\text{unb}} = 0.570$, 95% CI [0.22, 0.94], but not for East Asian faces, $t(35) = -0.25$, $p = .803$, $M_{\text{diff}} = -0.008$, 95% CI [-0.07, 0.05], Cohen's $d_{\text{unb}} = -0.038$, 95% CI [-0.34, 0.27] (Figure 6b).

A paired samples t-test yielded significantly higher CR for Caucasian faces (M = 0.796, 95% CI [0.76, 0.83]) than for East Asian faces (M = 0.735, 95% CI [0.69, 0.79]), $t(35) = 2.18$, $p = .036$, $M_{\text{diff}} = 0.060$, 95% CI [0.01, 0.12], Cohen's $d_{\text{unb}} = 0.469$, 95% CI [0.03, 0.92] (Figure 6a). In addition, a paired samples t-test on d' revealed significantly higher sensitivity for Caucasian (M = 1.384, 95% CI [1.13, 1.64]) than for East Asian faces (M = 0.857, 95% CI [0.64, 1.08]), $t(35) = 4.45$, $p < .001$, $M_{\text{diff}} = 0.527$, 95% CI [0.29, 0.77], Cohen's $d_{\text{unb}} = 0.733$, 95% CI [0.37, 1.12].

Discussion

Experiment 5 fully replicated the results of Experiment 1. Most importantly, a DF effect was again only observed for own-race faces, which further supports our earlier suggestion that a modulation of face memory is only possible when participants have acquired substantial expertise with a given class of faces.

To address the possibility that a failure to obtain DF for other-race faces in Experiment 1 might have resulted from low performance, we reduced the number of stimuli in Experiment 5 to decrease task difficulty. As a result, overall higher hit rates were observed compared to Experiment 1, for both own- and other-race faces. Yet, as in Experiment 1, we still did not find any evidence of DF for other-race faces. This clearly shows that a failure to find DF in Experiment 1 cannot be accounted for by chance performance. Rather, the present results strengthen our previous suggestion that a modulation of face memory appears to be limited to face categories we have substantial perceptual expertise with.

In Experiment 5, DF for own-race faces was found to be slightly less pronounced than in Experiment 1, albeit still significantly different from zero (see Figure 6b). This is unsurprising given that memory load was reduced overall which will arguably make it more likely for a given face to be remembered at test, irrespective of the DF cue it was paired with, thereby attenuating the DF effect.

General Discussion

The current series of experiments investigated DF of in- and out-group faces to test predictions derived from perceptual expertise and socio-cognitive accounts of the ORB. We observed distinct patterns of DF effects in five experiments. While Caucasian participants in Experiments 1 and 5 demonstrated DF for own- but not for other-race faces, East Asian participants with considerable expertise for the ethnic out-group showed comparable DF for own- and other race faces in Experiment 2. Experiment 3 and 4 revealed DF effects which did neither differ significantly between purely social in- and out-group faces nor between own- and other-gender faces. As discussed below, these results are well in line with a perceptual expertise account of the ORB, but are more difficult to integrate with socio-cognitive explanations.

An expertise-based explanation of the present findings can easily be integrated with the MDFS framework (Valentine, 1991). Given that perceptual expertise for other-race faces is reduced, MDFS postulates that their representations will be more similar to each other and clustered more densely in face space than own-race face representations. Accordingly, when a new other-race face is presented during learning, it will be projected into a more densely clustered area of the face space relative to own-race faces (see Figure 7a). Similarly. in the test phases of recognition memory experiments, learned and novel other-race faces will be more similar than learned and novel own-race faces, resulting in increased false alarm rates for the former category (Figure 7c). Importantly, in the present study, participants were additionally asked to remember half and to forget the other half of the faces presented during learning. Again, TBR and TBF other-race faces were perceptually more similar to each other than the respective own-race faces. Accordingly, if the TBF cue was successful and participants forgot the respective other-race item (Figure 7b), it would have nevertheless been projected to a face space location densely clustered with other representations when presented at test. Participants then more likely endorsed this face as “old”, although it was de facto confused with a neighbouring face representation (Figure 7d). This in turn substantially reduced differences between TBR and TBF other-race faces, and therefore resulted in small or even absent DF effects. Of note, the mechanism described here gives rise to a paradoxical effect: Other-race TBF faces, despite de facto being forgotten, will be “falsely remembered” as they are confused with a close neighbour.

Accordingly, MDFS provides a viable framework to explain the present results, although alternative expertise-based explanations, e.g., in terms of holistic processing, might also be possible. The present series of experiments was designed to test the contribution of socio-cognitive and motivational factors to the ORB, and therefore cannot distinguish between the various expertise-based accounts. Moreover, it has to be noted that the MDFS framework itself has been criticised. Although MDFS offers an intuitive explanation for a number of findings in face recognition research, such as memory advantages for distinctive and caricatured faces (e.g., Benson & Perrett, 1994; Lee, Byatt, & Rhodes, 2000), these accounts (often) fail to specify the exact number and nature of dimensions of the assumed space (but see Calder, Burton, Miller, Young, & Akamatsu, 2001). Typically, MDFS approaches derive their assumptions from illustrations of a two- or three-dimensional space. However, it can be shown mathematically that many of these assumptions do not hold in a space with a sufficiently large number of dimensions to accurately represent individual faces (Burton & Vokey, 1998). Importantly for the present purpose, the argument we offer here can be made without explicit reference to a multi-dimensional face space. Instead, our argument is based on the fundamental idea that faces that are perceived as similar are more likely to be mistaken for one another. In the present context, this will result in enhanced confusion among TBR and TBF other-race faces and thus reduced DF effects.

Experiments 2 to 5 were designed to test alternative explanations for the differential DF effect in our first experiment. First, one could argue that our finding of DF for own- but not other-race faces simply resulted from overall differences in difficulty between the two sets of stimuli, or from our set of East Asian faces being physically more similar compared to the Caucasian face set. These concerns were addressed in Experiment 2 which revealed comparable DF for own- and other-race faces in East Asian participants using the same stimuli as in Experiment 1.

Second, one might argue that the pattern observed in Experiment 1 was driven by automatic categorisation processes based on out-group-defining features (Sporer, 2001). Accordingly, other-race faces might have been automatically classified as belonging to an out-group and were thus not further processed at an individual level, generating the pattern of results observed in Experiment 1. This explanation would be hard to reconcile with the findings of Experiment 2, as Caucasian faces were probably still out-group faces for our East Asian participants, despite enhanced levels of contact. Nevertheless, to rule out this possibility also for Caucasian participants, Experiments 3 and 4 investigated DF for faces belonging to different social groups which did not differ with respect to expertise. We found a DF effect which did not interact with social group membership in Experiment 3, and also clear DF effects for own- and other-gender faces in Experiment 4, rendering it unlikely that social categorisation was driving the effect in Experiment 1. Instead, these findings are more in line with an expertise-based explanation of DF for own- and other-race faces. However, this conclusion should be met with caution given that we did not find unequivocal evidence for social categorisation in the present experiments.

Finally, it might be argued that the absence of DF for other-race faces in Experiment 1 simply resulted from guessing, as performance for this face category was generally low. To rule out this possibility, overall task difficulty was reduced in Experiment 5. However, despite a general increase in accuracy, the results of Experiment 1 were fully replicated, suggesting that the lack of DF for other-race faces cannot be accounted for by chance performance.

With respect to the motivational component of the DF instruction, we have suggested that the repeatedly presented TBR and TBF cues should motivate participants to initially encode all faces. Alternatively, it could be argued that the DF procedure generally reduces motivation to individuate the items given that half of the faces are, in fact, paired with a cue to forget during learning. We do not think this is likely, and both previous work and the present results provide evidence against this suggestion. From a theoretical perspective, as detailed in the introduction, a TBF cue is thought to stop rehearsal and to actively inhibit the previously presented item (e.g., Anderson & Hanslmayr, 2014; Basden et al., 1993, Nowicka et al., 2009). Both of these mechanisms arguably require motivation to initially process the presented material to be effective. Critically, by the time the cues are presented, the face stimulus has been removed from the screen and only its memory representation is available to the participant. In addition, in the present experiments, all faces were followed by a mask to prevent any visual aftereffect. Accordingly, if motivation was low and the resulting representations of the stimuli weak by the time the cue was presented, it would be inefficient to actively modulate this already weak representation. As a consequence, the resulting DF effects would arguably be moderate at best. However, we observed quite substantial DF effects ($d_{unb} = 0.789$ for own-race faces in Experiment 1, $d_{unb} = 1.080$ for own-gender faces in Experiment 4). Thus, it appears unlikely that, in general, the DF procedure reduces motivation to individuate the face stimuli.

Moreover, one could argue that comparable DF effects for own- and other-race faces in Experiment 2 resulted from East Asian participants' increased motivation to process Caucasian faces, given that these constitute the majority in their living environment, and we cannot definitely exclude this possibility on the basis of Experiment 2 alone. We note, however, that across the five experiments reported here, we consistently found DF for out-group faces when participants had substantial expertise with the respective out-group (Experiments 2, 3, and 4), and we repeatedly did not observe the effect when participants had only reduced expertise (Experiments 1 and 5). This overall pattern seems difficult to explain by varying motivation to process out-group faces, and an explanation based on expertise appears more parsimonious.

On a more general note, we acknowledge that throughout the paper references have been made to paradigms which used individuating instructions to study the mechanisms underlying the ORB (e.g., Hugenberg et al., 2007). In the introduction, we have argued that DF may be more motivating than typical recognition memory paradigms, which might represent an interesting parallel to the instruction manipulation. At the same time, we acknowledge that DF is quite different from the instruction manipulation. In the latter, participants receive information about the ORB prior to the experiment and are instructed to attend more to other-race faces and individuating features in them. In the DF paradigm, in contrast, participants are only instructed to follow the R and F cues, while no information is given with respect to how attention should be divided between own- and other-race faces. This may explain why the present results are somewhat different from those found in paradigms using individuating instructions. In particular, previous studies have reported that individuating instructions given to participants prior to the experiment can eliminate the ORB (Hugenberg et al., 2007; Rhodes et al., 2009; Young et al., 2010) while in the present study no evidence of DF for other-race faces was observed. However, it may well be that putting *more* effort into individuating other-race relative to own-race faces is needed to overcome the ORB, and that the lack of DF for other-race faces was due to the fact that the DF paradigm does not explicitly require this.

As detailed in the introduction, however, evidence for individuating instructions is not as clear-cut as originally thought. In fact, it has recently been suggested that instruction effects depend on the specific context in which the ORB is investigated (Wan et al., 2015). The authors reported no effect of instruction in Caucasian and East Asian participants tested with Caucasian and East Asian faces in Australia and concluded that in this context, the ORB resulted entirely from differences in perceptual expertise. An intriguing question then would be whether DF for other-race faces in Caucasian participants would be observable in a different cultural setting. For instance, one might speculate that White US participants show DF effects for African-American faces, as they presumably have considerably more expertise with such faces than our Caucasian participants had with East Asian faces. Accordingly, if in a given context perceptual expertise for out-group faces is relatively low (as for other-race faces in the present Experiments 1 and 5), this lack of perceptual expertise drives the bias in face memory (see also Stahl, Wiese, & Schweinberger, 2010; Wiese et al., 2014). If, however, expertise for out-group faces is relatively high (e.g., in the setting studied by Hugenberg and colleagues), motivation may well contribute substantially to the observed memory differences for own- and other-race faces.

In conclusion, both Caucasian (Experiments 1 and 5) and East Asian participants (Experiment 2) showed DF for the respective own-race faces. Additionally, East Asian participants demonstrated DF for other-race Caucasian faces, which was highly similar to the respective effect for own-race faces. Given that our East Asian sample had acquired substantial expertise with Caucasian faces while living in the UK, whereas our Caucasian participants did not have comparable expertise with East Asian faces, our results suggest that perceptual expertise is a prerequisite for a modulation of face memory by intentional processes or motivation. As recent socio-cognitive models of the ORB posit the exact opposite relationship between the two concepts, namely that expertise is only fully employed for faces perceivers are motivated to individuate, the present results are not in line with these suggestions. By contrast, perceptual expertise accounts offer a plausible interpretation of the present findings.

References

Ackerman, J. M., Shapiro, J. R., Neuberg, S. L., Kenrick, D. T., Becker, D. V., Griskevicius, V., . . . Schaller, M. (2006). They all look the same to me (unless they're angry): From out-group homogeneity to out-group heterogeneity. *Psychological Science, 17*(10), 836-840. doi:10.1111/j.1467-9280.2006.01790.x

Anderson, M. C. (2005). The role of inhibitory control in forgetting unwanted memories: A consideration of three methods. *Dynamic Cognitive Processes*, 159-189. doi:10.1007/4-431-27431-6_8

Anderson, M. C., & Hanslmayr, S. (2014). Neural mechanisms of motivated forgetting. *Trends in Cognitive Sciences, 18*(6), 279-292. doi:10.1016/j.tics.2014.03.002

Basden, B. H., & Basden, D. R. (1996). Directed forgetting: Further comparisons of the item and list methods. *Memory, 4*(6), 633-653. doi:10.1080/741941000

Basden, B. H., Basden, D. R., & Gargano, G. J. (1993). Directed forgetting in implicit and explicit memory tests: A comparison of methods. *Journal of Experimental Psychology-Learning Memory and Cognition, 19*(3), 603-616. doi:10.1037//0278-7393.19.3.603

Benson, P. J., & Perrett, D. I. (1994). Visual processing of facial distinctiveness. *Perception, 23*(1), 75-93. doi:10.1068/p230075

Bernstein, M. J., Young, S. G., & Hugenberg, K. (2007). The cross-category effect: Mere social categorization is sufficient to elicit an own-group bias in face recognition. *Psychological Science, 18*(8), 706-712. doi:10.1111/j.1467-9280.2007.01964.x

Bjork, R. A. (1970). Positive forgetting: The noniterference of Items intentionally forgotten. *Journal of Verbal Learning and Verbal Behavior, 9*(3), 255-268. doi:10.1016/s0022-5371(70)80059-7

Burton, A. M., & Vokey, J. R. (1998). The face-space typicality paradox: Understanding the face-space metaphor. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 51*(3), 475-483. doi:10.1080/713755768

Calder, A. J., Burton, A. M., Miller, P., Young, A. W., & Akamatsu, S. (2001). A principal component analysis of facial expressions. *Vision Research, 41*(9), 1179-1208. doi:10.1016/s0042-6989(01)00002-5

Costa, P. T., & McCrea, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Crookes, K., & Rhodes, G. (2017). Poor recognition of other-race faces cannot always be explained by a lack of effort. *Visual Cognition*. doi:10.1080/13506285.2017.1311974

Cumming, G. (2012). *Understanding the New Statistics. Effect Sizes, Confidence Intervals, and Meta-Analysis*. New York: Routledge.

Cumming, G., & Calin-Jageman, R. (2017). *Introduction to the New Statistics: Estimation, Open Science, and Beyond*. New York: Routledge.

Fawcett, J. M., & Taylor, T. L. (2008). Forgetting is effortful: Evidence from reaction time probes in an item-method directed forgetting task. *Memory & Cognition, 36*(6), 1168-1181. doi:10.3758/mc.36.6.1168

Fitzgerald, R. J., Price, H. L., & Oriet, C. (2013). Intentionally Forgetting Other-Race Faces: Costs and Benefits? *Journal of Experimental Psychology: Applied, 19*(2), 130-142. doi:10.1037/a0033287

Goernert, P. N., Corenblum, B., & Otani, H. (2011). Directed forgetting of faces: The role of response criterion. *Quarterly Journal of Experimental Psychology, 64*(10), 1930-1938. doi:10.1080/17470218.2011.595806

Hauswald, A., & Kissler, J. (2008). Directed forgetting of complex pictures in an item method paradigm. *Memory, 16*(8), 797-809. doi:10.1080/09658210802169087

Hauswald, A., Schulz, H., Iordanov, T., & Kissler, J. (2011). ERP dynamics underlying successful directed forgetting of neutral but not negative pictures. *Social Cognitive and Affective Neuroscience, 6*(4), 450-459. doi:10.1093/scan/nsq061

Hayward, W. G., Crookes, K., & Rhodes, G. (2013). The other-race effect: Holistic coding differences and beyond. *Visual Cognition, 21*(9-10), 1224-1247. doi:10.1080/13506285.2013.824530

Hehman, E., Mania, E. W., & Gaertner, S. L. (2010). Where the division lies: Common ingroup identity moderates the cross-race facial-recognition effect. *Journal of Experimental Social Psychology, 46*(2), 445-448. doi:10.1016/j.jesp.2009.11.008

Herlitz, A., & Loven, J. (2013). Sex differences and the own-gender bias in face recognition: A meta-analytic review. *Visual Cognition, 21*, 1306-1336. doi: 10.1080/13506285.2013.823140

Herzmann, G., & Curran, T. (2013). Neural Correlates of the In-Group Memory Advantage on the Encoding and Recognition of Faces. *Plos One, 8*(12). doi:10.1371/journal.pone.0082797

Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of Experimental Social Psychology, 43*(2), 334-340. doi:10.1016/j.jesp.2006.02.010

Hugenberg, K., Wilson, J. P., See, P. E., & Young, S. G. (2013). Towards a synthetic model of own group biases in face memory. *Visual Cognition, 21*(9-10), 1392-1417. doi:10.1080/13506285.2013.821429

Hugenberg, K., Young, S. G., Bernstein, M. J., & Sacco, D. F. (2010). The Categorization-Individuation Model: An Integrative Account of the Other-Race Recognition Deficit. *Psychological Review, 117*(4), 1168-1187. doi:10.1037/a0020463

Kloth, N., Shields, S. E., & Rhodes, G. (2014). On the Other Side of the Fence: Effects of Social Categorization and Spatial Grouping on Memory and Attention for Own-Race and Other-Race Faces. *Plos One, 9*(9). doi:10.1371/journal.pone.0105979

Lee, K., Byatt, G., & Rhodes, G. (2000). Caricature effects, distinctiveness, and identification: Testing the face-space framework. *Psychological Science, 11*(5), 379-385. doi:10.1111/1467-9280.00274

Lehman, E. B., McKinley-Pace, M., Leonard, A. M., Thompson, D., & Johns, K. (2001). Item-cued directed forgetting of related words and pictures in children and adults: Selective rehearsal versus cognitive inhibition. *Journal of General Psychology, 128*(1), 81-97. doi:10.1080/00221300109598900

MacLeod, C. M. (1999). The item and list methods of directed forgetting: Test differences and the role of demand characteristics. *Psychonomic Bulletin & Review, 6*(1), 123-129. doi:10.3758/bf03210819

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology Public Policy and Law, 7*(1), 3-35. doi:10.1037/1076-8971.7.1.3

Metzger, M. M. (2011). Directed Forgetting: Differential Effects on Typical and Distinctive Faces. *Journal of General Psychology, 138*(2), 155-168. doi:10.1080/00221309.2011.557407

Michel, C., Rossion, B., Han, J., Chung, C. S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of one's own race. *Psychological Science, 17*(7), 608-615. doi:10.1111/j.1467-9280.2006.01752.x

Nowicka, A., Jednorog, K., Wypych, M., & Marchewka, A. (2009). Reversed old/new effect for intentionally forgotten words: An ERP study of directed forgetting. *International Journal of Psychophysiology, 71*(2), 97-102. doi:10.1016/j.ijpsycho.2008.06.009

Paller, K. A., Bozic, V. S., Ranganath, C., Grabowecky, M., & Yamada, S. (1999). Brain waves following remembered faces index conscious recollection. *Cognitive Brain Research, 7*(4), 519-531. doi:10.1016/s0926-6410(98)00050-0

Paz-Caballero, M. D., Menor, J., & Jimenez, J. M. (2004). Predictive validity of event-related potentials (ERPs) in relation to the directed forgetting effects. *Clinical Neurophysiology, 115*(2), 369-377. doi:10.1016/j.clinph.2003.09.011

Pica, E., Warren, A. R., Ross, D. F., & Kehn, A. (2015). Choosing Your Words and Pictures Wisely: When Do Individuation Instructions Reduce the Cross-Race Effect? *Applied Cognitive Psychology, 29*(3), 360-368. doi:10.1002/acp.3112

Quinlan, C. K., Taylor, T. L., & Fawcett, J. M. (2010). Directed Forgetting: Comparing Pictures and Words. *Canadian Journal of Experimental Psychology-Revue Canadienne De Psychologie Experimentale, 64*(1), 41-46. doi:10.1037/a0016569

Reber, P. J., Siwiec, R. M., Gitleman, D. R., Parrish, T. B., Mesulam, M. M., & Paller, K. A. (2002). Neural correlates of successful encoding identified using functional magnetic resonance imaging. *Journal of Neuroscience, 22*(21), 9541-9548.

Rhodes, G., Locke, V., Ewing, L., & Evangelista, E. (2009). Race coding and the other-race effect in face recognition. *Perception, 38*(2), 232-241. doi:10.1068/p6110

Shriver, E. R., & Hugenberg, K. (2010). Power, individuation, and the cross-race recognition deficit. *Journal of Experimental Social Psychology, 46*(5), 767-774. doi:10.1016/j.jesp.2010.03.014

Shriver, E. R., Young, S. G., Hugenberg, K., Bernstein, M. J., & Lanter, J. R. (2008). Class, race, and the face: Social context modulates the cross-race effect in face recognition. *Personality and Social Psychology Bulletin, 34*(2), 260-274. doi:10.1177/0146167207310455

Sporer, S. L. (2001). Recognizing faces of other ethnic groups - An integration of theories. *Psychology Public Policy and Law, 7*(1), 36-97. doi:10.1038//1076-8971.7.1.36

Stahl, J., Wiese, H., & Schweinberger, S. R. (2010). Learning task affects ERP-correlates of the own-race bias, but not recognition memory performance. *Neuropsychologia, 48*(7), 2027-2040. doi:10.1016/j.neuropsychologia.2010.03.024

Steffens, M. C., Landmann, S., & Mecklenbräuker, S. (2013). Participant sexual orientation matters: New evidence on the gender bias in face recognition. *Experimental Psychology, 60*(5), 362-367. doi: 10.1027/1618-3169/a000209

Tanaka, J. W., Kiefer, M., & Bukach, C. M. (2004). A holistic account of the own-race effect in face recognition: evidence from a cross-cultural study. *Cognition, 93*(1), B1-B9. doi:10.1016/j.cognition.2003.09.011

Tullis, J. G., Benjamin, A. S., & Liu, X. P. (2014). Self-pacing study of faces of different races: metacognitive control over study does not eliminate the cross-race recognition effect. *Memory & Cognition, 42*(6), 863-875. doi:10.3758/s13421-014-0409-y

Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 43*(2), 161-204. doi:10.1080/14640749108400966

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: the effects of race and distinctiveness. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 44*(4), 671-703. doi:10.1080/14640749208401305

Valentine, T., Lewis, M. B., & Hills, P. J. (2016). Face-space: A unifying concept in face recognition research. *Quarterly Journal of Experimental Psychology, 69*(10), 1996-2019. doi:10.1080/17470218.2014.990392

Wan, L. L., Crookes, K., Reynolds, K. J., Irons, J. L., & McKone, E. (2015). A cultural setting where the other-race effect on face recognition has no social-motivational component and derives entirely from lifetime perceptual experience. *Cognition, 144*, 91-115. doi:10.1016/j.cognition.2015.07.011

Wickens, T. D. (2002). *Elementary signal detection theory*. Oxford: Oxford University Press.

Wiese, H. (2012). The role of age and ethnic group in face recognition memory: ERP evidence from a combined own-age and own-race bias study. *Biological Psychology, 89*(1), 137-147. doi:10.1016/j.biopsycho.2011.10.002

Wiese, H., Kaufmann, J. M., & Schweinberger, S. R. (2014). The Neural Signature of the Own-Race Bias: Evidence from Event-Related Potentials. *Cerebral Cortex, 24*(3), 826-835. doi:10.1093/cercor/bhs369

Wiese, H., & Schweinberger, S. R. (2018). Inequality between biases in face memory: Event-related potentials reveal dissociable neural correlates of own-race and own-gender biases. *Cortex, 101*, 119-135. doi: 10.1016/j.cortex.2018.01.016

Wolff, N., Kemter, K., Schweinberger, S. R., & Wiese, H. (2014). What drives social in-group biases in face recognition memory? ERP evidence from the own-gender bias. *Social Cognitive and Affective Neuroscience, 9*(5), 580-590. doi: 10.1093/scan/nst024

Woodward, A. E., & Bjork, R. A. (1971). Forgetting and remembering in free recall: Intentional and unintentional. *Journal of Experimental Psychology, 89*(1), 109-116. doi:10.1037/h0031188

Wright, D. B., & Sladden, B. (2003). An own gender bias and the importance of hair in face recognition. *Acta Psychologica, 114*(1), 101-114. doi: 10.1016.S0001-6918(03)00052-0

Young, S. G., Bernstein, M. J., & Hugenberg, K. (2010). When do own-group biases in face recognition occur? Encoding versus post-encoding. *Social Cognition, 28*(2), 240-250. doi:10.1521/soco.2010.28.2.240

Young, S. G., & Hugenberg, K. (2012). Individuation Motivation and Face Experience Can Operate Jointly to Produce the Own-Race Bias. *Social Psychological and Personality Science, 3*(1), 80-87. doi:10.1177/1948550611409759

Young, S. G., Hugenberg, K., Bernstein, M. J., & Sacco, D. F. (2012). Perception and Motivation in Face Recognition: A Critical Review of Theories of the Cross-Race

Effect. *Personality and Social Psychology Review, 16*(2), 116-142.
doi:10.1177/1088868311418987

Figure Captions

Figure 1. Exemplary trial structure of the learning phases of (a) Experiments 1 and 2 and (b) Experiment 3. Please note that for copyright reasons, images depicted here are not the pictures used in the experiment. Images are reprinted with full permission of the depicted persons.

Figure 2. Results of Experiment 1. a) Mean accuracy for remember (R) and forget (F) items, as well as correct rejections (CR) for both Caucasian and East Asian faces. b) Mean DF effects (R-F) for Caucasian and East Asian faces respectively. Error bars depict 95% CI, grey dots show data from individual participants.

Figure 3. Results of Experiment 2. a) Mean accuracy for remember (R) and forget (F) items, as well as correct rejections (CR) for both Caucasian and East Asian faces. b) Mean DF effects (R-F) for Caucasian and East Asian faces respectively. Error bars depict 95% CI, grey dots show data from individual participants.

Figure 4. Results of Experiment 3. a) Mean accuracy for remember (R) and forget (F) items, for in- and out-group faces respectively, and the CR rate. b) Mean DF effects (R-F) for in- and out-group faces. Error bars depict 95% CI, grey dots show data from individual participants.

Figure 5. Results of Experiment 4. a) Mean accuracy for remember (R) and forget (F) items, as well as correct rejections (CR) for both female and male faces. b) Mean DF effects (R-F) for female and male faces. Error bars depict 95% CI, grey dots show data from individual participants.

Figure 6. Results of Experiment 5. a) Mean accuracy for remember (R) and forget (F) items, as well as correct rejections (CR) for both Caucasian and East Asian faces. b) Mean DF effects (R-F) for Caucasian and East Asian faces respectively. Error bars depict 95% CI, grey dots show data from individual participants.

Figure 7. Schematic illustration for differential DF effects for own- and other-race faces, given reduced perceptual expertise for the latter category. See text for a more detailed description.

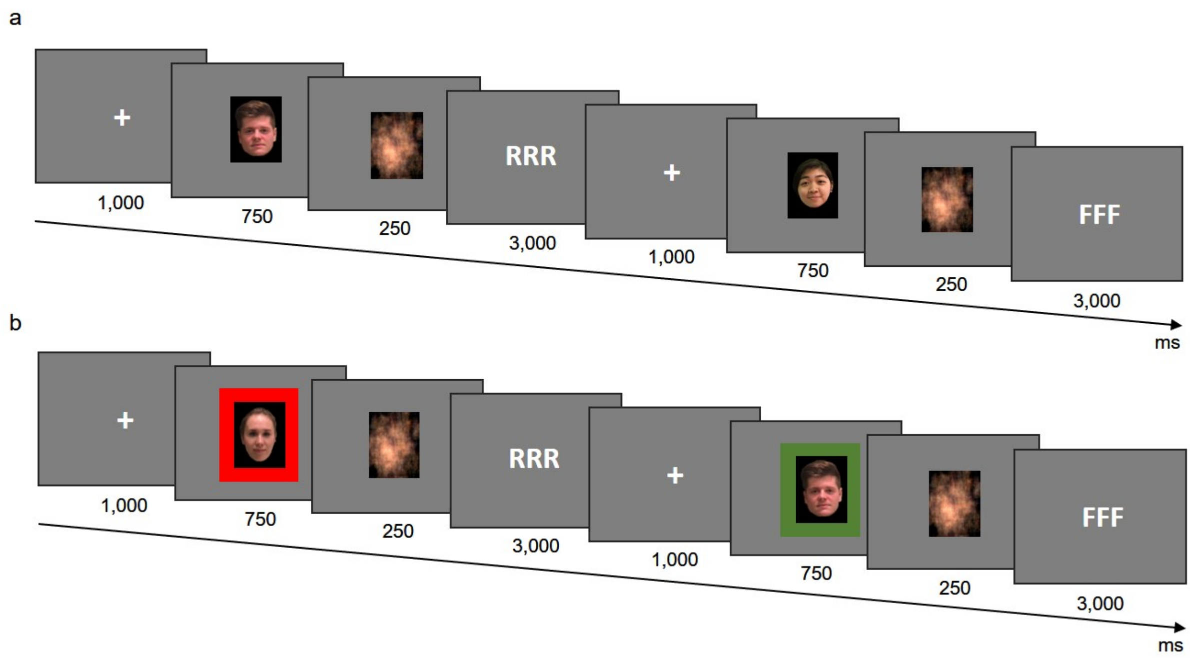
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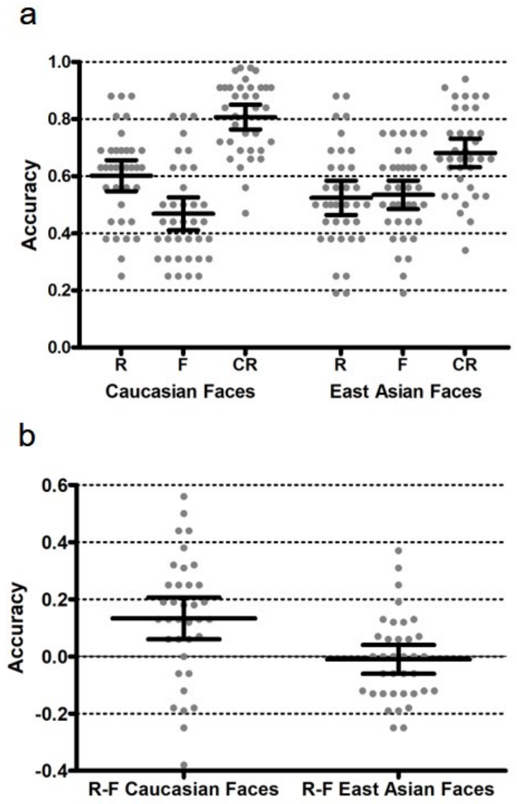
Figure 1.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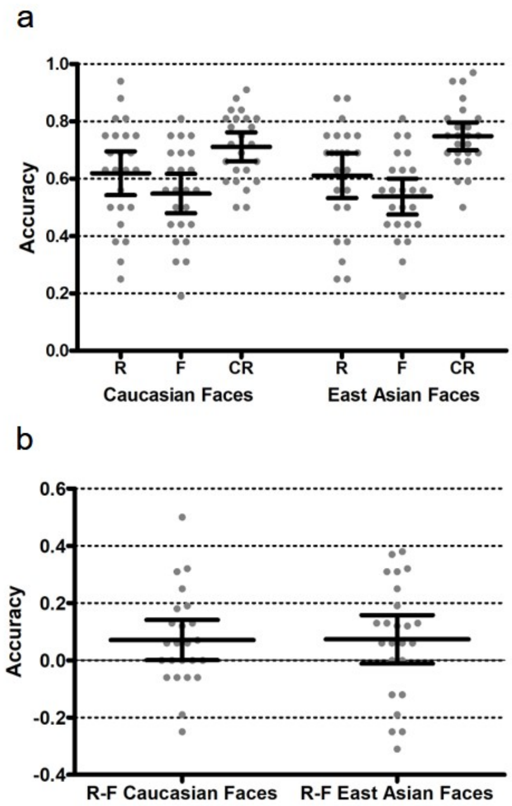
Accuracy
R-F Caucasian Faces
R-F East Asian Faces

Figure 2.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CR
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Caucasian Faces
East Asian Faces
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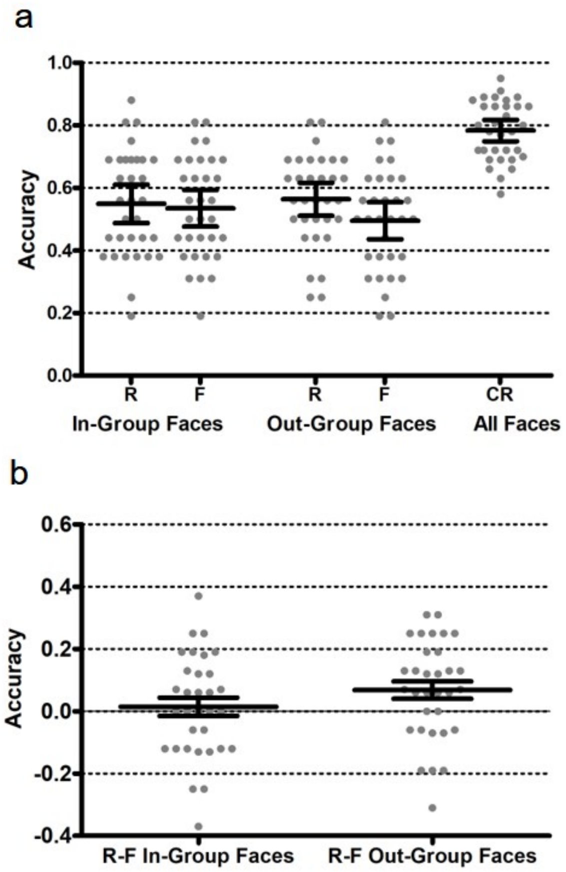
-0.4
Accuracy
R-F Caucasian Faces
R-F East Asian Faces

Figure 3.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In-Group Faces
Out-Group Faces
All Faces
b
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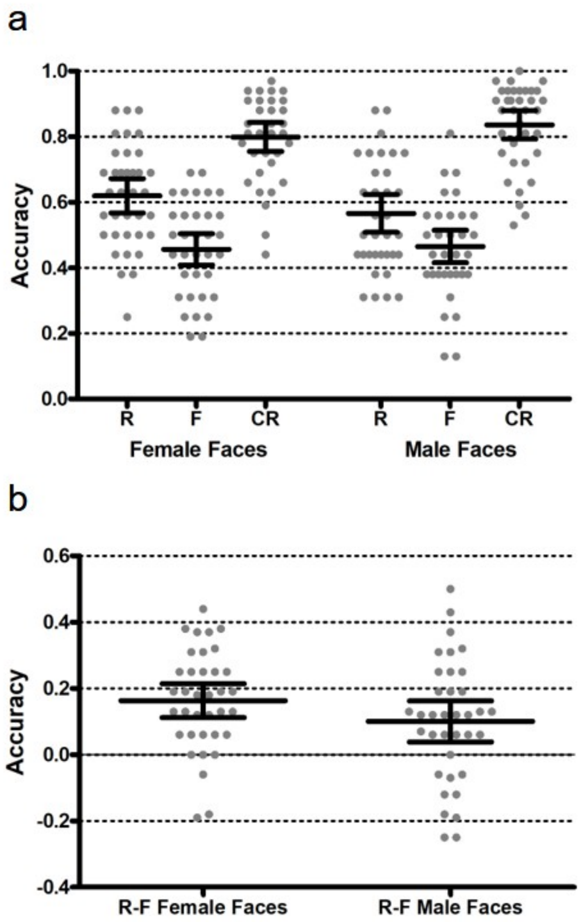
-0.4
Accuracy
R-F In-Group Faces
R-F Out-Group Faces

Figure 4.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Accuracy
R
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CR
Female Faces
R
F
CR
Male Faces
b
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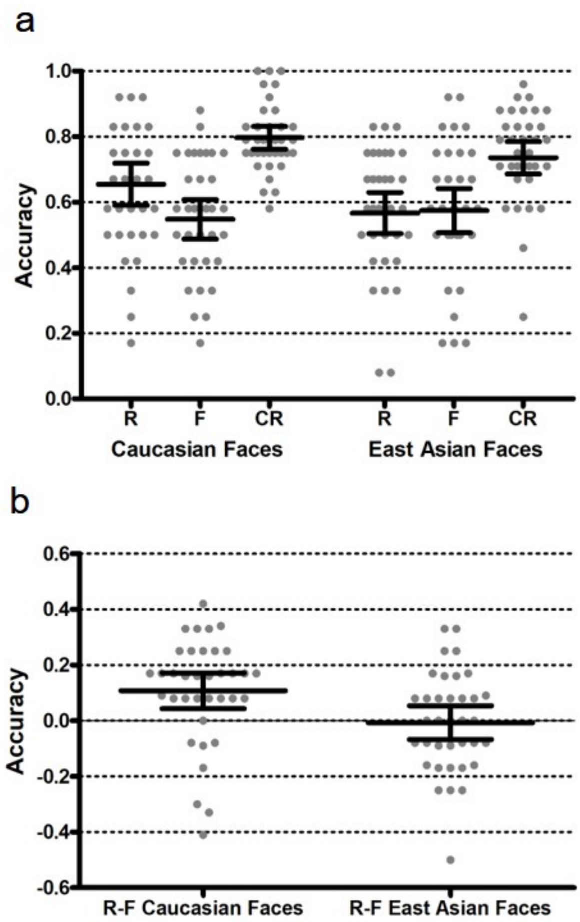
Accuracy
R-F Female Faces
R-F Male Faces

Figure 5.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Caucasian Faces
East Asian Faces
b
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-0.2
-0.4
-0.6
Accuracy
R-F Caucasian Faces
R-F East Asian Faces

Figure 6.

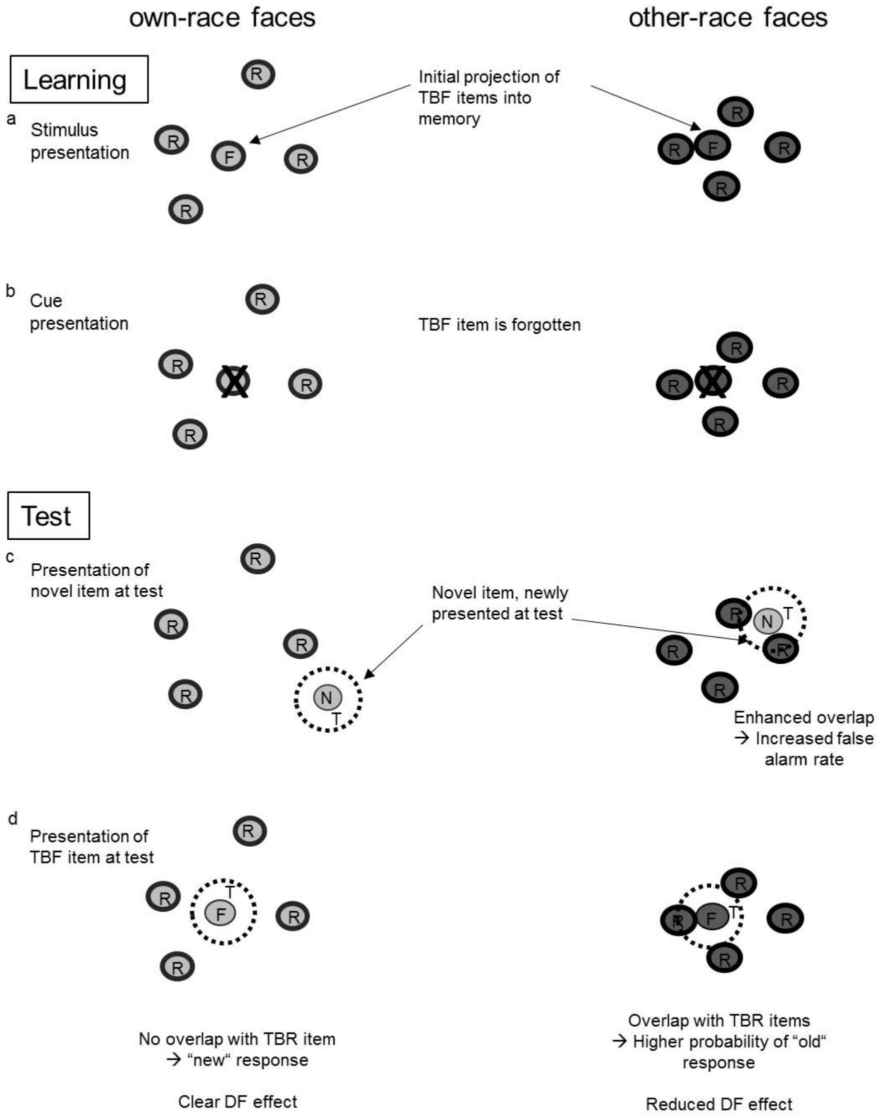
own-race faces
other-race faces
Learning
a
Stimulus presentation
Initial projection of TBF items into memory
b
Cue presentation
TBF item is forgotten
Test
c
Presentation of novel item at test
Novel item, newly presented at test
Enhanced overlap → Increased false alarm rate
d
Presentation of TBF item at test
No overlap with TBR item → "new" response
Clear DF effect
Overlap with TBR items → Higher probability of "old" response
Reduced DF effect

Figure 7.